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“Rural-Urban Interdependence, Structural Change, and Development”

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Abstract

This paper presents a model of development that explicitly incorporates the interaction between rural agriculture and urban non-agriculture. The increase of capital stock leads to capital intensive agriculture and the reallocation of labor from agriculture to non-agriculture. People who migrate to urban areas create new intermediate goods and enhance non-agricultural productivity, which, in turn, causes capital accumulation and capital intensive agriculture. This mechanism creates multiple steady states, and the economy may fall into a poverty trap or experience sustained growth.

Keywords: Structural change, Labor migration, Economic development, Multiple steady states

JEL Classification: O11, O12, O41, R11

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1 Introduction

It is widely observed that, as the economy develops, employment, production, and consumption move from traditional agricultural sectors in rural areas to modern non-agricultural sectors in urban areas, such as manufacturing. This phenomenon is often called structural change or structural transformation. With the implicit assumption that the economy is closed, it is often argued that, because food is a necessity, the improvement of agricultural productivity is a precondition for the economy to successfully accomplish such structural change and begin modern economic growth. This point is clarified by the closed economy version of the Matsuyama (1992) model: the improvement of the total factor productivity (TFP) in agriculture releases labor from agriculture to manufacturing and promotes growth.[1] On the other hand, technologies in manufacturing (non-agriculture) improve productivity in agriculture by supplying intermediate inputs, including pesticides, chemical fertilizers, and tractors.[2] Yang and Zhu (2013) argue that the development of agriculture is the result of technological progress in manufacturing. Although insightful, the focus of these studies is the effect of exogenous productivity changes on structural change and growth.

For a better understanding of the relationship between structural change and economic development, it is necessary to construct a model in which both agricultural and manufacturing productivities are endogenously determined through the interaction of the two sectors.[3] Murata (2002) is one of the few studies that focuses on such in-

[1] Eswaran and Kotwal (1993), Kögel and Prskawetz (2001), and Gollin et al. (2007) also analyze the effect of the exogenous improvement of agricultural productivity on structural change.

[2] Restuccia et al. (2008) show that output per worker in agriculture is positively correlated with the intensive use of industry-supplied intermediate inputs. See also Murata (2002) for a case study on Japan.

[3] Matsuyama (1992) remarks that the technological advances in manufacturing should certainly improve agricultural productivity by supplying better and cheaper intermediate inputs, and that investigating two-way interactions between industrialization and agriculture is essential to understand the role of agriculture for economic development.

teractions between agriculture and manufacturing. In Murata's (2002) model, people migrate to urban areas to innovate new intermediate goods that enhance agricultural productivity, and the technology in non-agriculture is enhanced by people who migrate from rural to urban areas.

This paper proposes a dynamic general equilibrium model that incorporates rural-urban interdependence in the spirit of Murata (2002). There are four production sectors: the agricultural, manufacturing, intermediate goods, and capital good sectors. The agricultural sector is in rural areas, and the other three sectors are in urban areas. The market structures of the agricultural, manufacturing, and capital good sectors are perfect competition. The agricultural good is produced by using labor and the capital good in a Cobb-Douglass production function. The manufacturing good is produced by combining the differentiated intermediate goods in a technology with a constant elasticity of substitution whose value is greater than one. A familiar feature of such a CES technology is that the greater the number of available intermediate goods, the higher the productivity of each intermediate good. The capital good, or simply capital, is produced by transforming the manufacturing good in one period. In the intermediate goods sector, a fixed size of the capital good is used to establish a firm, following which each firm employs labor to produce an intermediate good. Because of the fixed cost of setting up a firm, the technology in this sector exhibits increasing returns to scale, and the market structure is monopolistic competition. The entry and exit of firms are free. Individuals consume the agricultural and manufacturing goods. Their preferences are non-homothetic, and the income elasticity of the agricultural good is less than one, which is known as Engel's law.

In the model economy, the accumulation of capital lowers its price, which causes capital-intensive agriculture and raises the labor wage income. Because the income

elasticity of the agricultural good is less than one, the growth of the demand for the agricultural good is not as large as that of income, and labor is released from agriculture. At the same time, the reduction of the capital price also lowers the fixed cost of establishing an intermediate good firm, and consequently, more firms enter the market, hire people who are released from agriculture, and create new intermediate goods. The variety expansion of intermediate goods raises their own productivity in manufacturing, which promotes the further accumulation of capital. Thus, the increase of capital in the current period causes the labor reallocation and the increase of capital stock in the next period.

Whether such a joint evolution of capital accumulation and structural change is realized in equilibrium depends on the production technologies, in particular, the manufacturing technology. If the elasticity of substitution among the intermediate goods is small in manufacturing, then the markup rate and the gross profit for intermediate good firms are large. Once the fixed cost decreases, the large profit induces many intermediate good firms to enter the market, the variety of intermediate goods is greatly expanded, and capital is rapidly accumulated. This mechanism creates multiple steady states, and the economy may fall into a poverty trap. If the initial capital level is low and the price of capital is high, then agriculture is labor intensive, and the number of intermediate goods is small because of the high fixed cost of setting up a firm. As a consequence, capital in the next period becomes lower, and the economy falls into a poverty trap. On the other hand, if the economy starts with a high level of capital stock, then the mechanism generates a virtuous circle, and the economy experiences permanent growth. That is, because of a large capital stock, the price of capital is low, agriculture is capital intensive, many varieties of intermediate goods are supplied, and capital accumulation is accelerated. In the case where the elasticity of substitution

is large in manufacturing, the economy converges to a stable steady state and ceases to grow. The economy may or may not experience structural change in the transition process.

This paper is associated with the literature on structural change and economic development in terms of the interdependence between rural and urban sectors. Murata (2002) is highly related in both the motivation and the model structure. Developing a model of rural-urban interdependence, Murata (2002) proves that there exists multiple equilibria and the economy may fall into a low development trap. In the low development trap, low labor wages lead to a high expenditure share on the agricultural good due to non-homothetic preferences, which implies that substantial labor force must be devoted in agriculture. This prevents labor migration to urban sectors and narrows the range of available intermediate inputs, which in turn causes a high price of the composite of the intermediate inputs and low labor wages. A difference of this paper from Murata (2002) is that a low development trap is captured by a model of multiple steady states with a unique equilibrium path, while in Murata (2002), it is captured by a static model with multiple equilibria.

Yang and Zhu (2013) also consider a model in which agricultural productivity is enhanced by using intermediate inputs supplied by manufacturing, and argue that technological progress in manufacturing is a precondition of the modernization of agriculture and sustained economic growth. Yang and Zhu (2013) show that as manufacturing TFP grows, the price of the manufacturing good declines and farmers are induced to use the manufacturing good as an input; that is, the modernization of agriculture is realized. Although the TFPs in the agricultural and manufacturing sectors grow exogenously in the Yang and Zhu (2013) model, this paper endogenizes both productivities in the two sectors through the rural-urban interdependence.

This paper is also related to many other studies that analyze labor reallocation and economic growth in a two-sector model, e.g., Matsuyama (1992), Kögel and Prskawetz (2001), and Gollin et al. (2007).[4] Yuki (2008) develops a two-sector overlapping generations model that incorporates non-homothetic preferences and imperfect credit markets, and shows that the agricultural TFP and the initial income distribution matter for whether an economy succeeds in structural change and achieves modern economic growth. Caselli and Coleman (2001) argue that the declining cost of education to acquire skills to engage in non-agricultural work in urban areas facilitates structural change and regional convergence in the United States. Hayashi and Prescott (2008) emphasize that the social norm that forced the son designated as heir to stay in agriculture was the barrier to rural-to-urban migration in prewar Japan.[5]

The rest of this paper is structured as follows. Section 2 describes the model. Section 3 solves the model and characterizes the equilibrium. Section 4 discusses the equilibrium dynamics. Section 5 concludes.

2 The Model

Time is discrete and indexed by $t \geq 0$. The economy is closed and represented by a non-overlapping generations model inhabited by individuals who live for only one period.

[4]Differently from Matsuyama (1992) and Kögel and Prskawetz (2001), in Gollin et al. (2007), agriculture uses intermediate goods supplied by manufacturing. However, the timing of structural change depends on only the agricultural TFP, and as long as agricultural productivity grows exogenously, structural change is eventually realized. This point is largely different from Yang and Zhu (2013). Rather than a feedback effect of manufacturing on agriculture through the supply of intermediate goods, Grossmann (2013) assumes that technological progress in modern industry (manufacturing) achieved by R&D activities spills over to raise agricultural TFP.

[5]There is a strand of literature that attempts to reconcile the Kaldor facts with the Kuznets facts in the growth process. Kongsamut et al. (2001), Ngai and Pissarides (2007), and Acemoglu and Guerrieri (2008) are notable examples. See Herrendorf et al. (2014) for a list of references on this subject. The interest of this paper is considering whether the economy starts the steady growth studied in such literature.

There are four production sectors. One is a traditional agricultural sector in rural areas, and the others are modern sectors in urban areas: a manufacturing, intermediate goods, and a capital good sectors. The intermediate goods are used as factor inputs in the manufacturing sector. The manufacturing good is either consumed or used to produce the capital good, while the agricultural good is used only for consumption. Although the agricultural, manufacturing, and capital good markets are perfectly competitive, the intermediate goods market is monopolistically competitive. The price of the agricultural good is normalized to one. Individuals supply labor to either the agricultural sector or the intermediate goods sector. Labor is perfectly mobile across the two sectors, which equalizes the equilibrium wage rates in these two sectors.

2.1 Agriculture

The agricultural good is produced according to a Cobb-Douglass production function,

$$y_{at} = Ak_{at}^{\gamma} l_{at}^{1-\gamma}, \quad \gamma \in (0,1), \tag{1}$$

where y_{at} is the output of the agricultural good, k_{at} and l_{at} are the capital good and labor input, respectively. The subscript t denotes the time period. $A > 0$ is the total factor productivity (TFP) that captures any effects that do not come from the capital and labor services (e.g., the effects from climate, soil, social infrastructures, policies, and institutions). Because each input receives its marginal product,

$$r_t = A\gamma k_{at}^{\gamma-1} l_{at}^{1-\gamma}, \tag{2}$$

$$w_t = A(1-\gamma) k_{at}^{\gamma} l_{at}^{-\gamma}, \tag{3}$$

where r_t and w_t are the price of the capital good and the labor wage, respectively. From (2) and (3), the capital-labor ratio in agriculture is given by

$$\frac{k_{at}}{l_{at}} = \frac{\gamma}{1-\gamma}\frac{w_t}{r_t}. \tag{4}$$

2.2 Manufacturing

The manufacturing production uses differentiated intermediate goods in the following CES production function:

$$X_t = \left(\int_0^{n_t} x_{it}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1,$$

where X_t is the output of the manufacturing good, n_t is the number of available intermediate goods, x_{it} is the input of intermediate good $i \in [0, n_t]$, and σ is the elasticity of substitution among the intermediate goods. Because the marginal cost of producing the manufacturing good must be equal to its price,

$$P_t = \left(\int_0^{n_t} p_{it}^{1-\sigma} di \right)^{\frac{1}{1-\sigma}},$$

where P_t is the price of the manufacturing good, and p_{it} is the price of the intermediate good i. The demand for the intermediate good i is given by

$$x_{it} = \left(\frac{p_{it}}{P_t} \right)^{-\sigma} X_t. \tag{5}$$

2.3 Intermediate goods

Monopolistically competitive firms employ capital and labor to produce differentiated intermediate goods. As in Koska and Stähler (2014), a fixed amount of capital is used

to establish a firm and variable amounts of labor are used for production. Specifically, one unit of capital is required to set up a firm, and after paying the fixed cost, each firm can produce x_{it} units of its intermediate good by hiring ax_{it} units of labor. Each firm maximizes its profit, $\pi_{it} = (p_{it} - aw_t)x_{it} - r_t$, subject to the demand function (5). This yields $p_{it} = [\sigma/(\sigma - 1)]aw_t$, where $\sigma/(\sigma - 1)$ is the markup rate. Because p_{it} is independent of the variety index i, x_{it} and π_{it} are also independent of i. Let us drop the variety index i, accordingly, and denote $p_t \equiv p_{it}$, $x_t \equiv x_{it}$, and $\pi_t \equiv \pi_{it}$. Moreover, for notational simplicity, I choose the unit of measurement so that $a = (\sigma - 1)/\sigma$. The results are summarized as

$$p_t = w_t, \quad x_t = \left(\frac{w_t}{P_t}\right)^{-\sigma} X_t.$$

These results give the price index and the quantity of the manufacturing good as a function of n_t:

$$P_t = n_t^{\frac{1}{1-\sigma}} w_t, \tag{6}$$

$$X_t = n_t^{\frac{\sigma}{\sigma-1}} x_t. \tag{7}$$

Entry and exit to the intermediate goods market are free. This free entry condition allows no firm to earn strictly positive profit, and, as a result, the equilibrium profit must be zero: $\pi_t = (1 - a)p_t x_t - r_t = 0$. This zero profit condition is rewritten as

$$\frac{1}{\sigma} w_t x_t = r_t, \tag{8}$$

which is used to pin down the equilibrium value of n_t. The environments of the manufacturing and intermediate goods sectors are the same as in Kögel and Prskawetz (2001), except that the fixed cost of intermediate good firms is associated with the

capital input in this paper, while it is associated with the labor input in Kögel and Prskawetz (2001).

2.4 Capital good

There are infinitely lived capital producers, who transform one unit of the manufacturing good in period t into the capital good in the next period $t+1$. That is, their production technology is $k_{t+1} = X_{kt}$, where k_{t+1} is the output of the capital good at period $t+1$ and X_{kt} is the input of the manufacturing good. They do not discount future payoffs. These imply $r_t = P_{t-1}$ in equilibrium. The capital good fully depreciates in one period. The capital good is also simply called capital.

2.5 Individuals

A continuum of homogeneous individuals with unit mass, who live for only one period, is born in every period. They supply one unit of labor inelastically to either the agricultural sector or an intermediate good firm, and earn the wage w_t. Individuals have the following non-homothetic preference represented by

$$u(c_{at}, c_{mt}) = \begin{cases} c_{at} & \text{if } c_{at} < \overline{c}, \\ \overline{c} + (c_{at} - \overline{c})^{\alpha} c_{mt}^{1-\alpha} & \text{if } c_{at} \geq \overline{c}, \end{cases} \tag{9}$$

where $\overline{c} > 0$, $\alpha \in [0, 1)$, and c_{at} and c_{mt} are the consumption of the agricultural and the manufacturing good, respectively. A special case of (9) in which $\alpha = 0$ has been used in the literature, including Eswaran and Kotwal (1993), Laitner (2000), and Yang and Zhu (2013); I focus on the case of $\alpha = 0$ for notational and calculation simplicity.[6]

[6]I will mention that the results of this paper do not depend on the choice of $\alpha = 0$ at the end of Section 4.

Because the budget constraint is $c_{at} + P_t c_{mt} = w_t$, the demand for each good is given by

$$c_{at} = w_t, \quad c_{mt} = 0, \quad \text{if } w_t < \overline{c}, \tag{10}$$

and

$$c_{at} = \overline{c}, \quad c_{mt} = \frac{w_t - \overline{c}}{P_t}, \quad \text{if } w_t \geq \overline{c}. \tag{11}$$

Individuals spend all their income on the agricultural good when their income is so low that $w_t < \overline{c}$. When $w_t \geq \overline{c}$, individuals are satiated with the agricultural consumption at $c_{at} = \overline{c}$ and spend all their remaining income on the manufacturing good.

3 Equilibrium

This section solves the model and characterizes the equilibrium. Two cases are considered: (i) $w_t \geq \overline{c}$ (the high-income case) and (ii) $w_t < \overline{c}$ (the low-income case).

3.1 High-income case

In the case of $w_t \geq \overline{c}$, the agricultural market clears if $\overline{c} = y_{at}$. Because the agricultural production function and the capital-labor ratio in agriculture is given respectively by (1) and (4),

$$l_{at} = \frac{\overline{c}}{A} \left(\frac{\gamma}{1-\gamma} \right)^{-\gamma} w_t^{-\gamma} r_t^{\gamma}, \tag{12}$$

$$k_{at} = \frac{\overline{c}}{A} \left(\frac{\gamma}{1-\gamma} \right)^{1-\gamma} w_t^{1-\gamma} r_t^{\gamma-1}. \tag{13}$$

Because $y_{at} = r_t k_{at} + w_t l_{at}$, (12) and (13) yield

$$w_t^{1-\gamma} r_t^{\gamma} = A \left(\frac{\gamma}{1-\gamma} \right)^{\gamma} (1-\gamma), \tag{14}$$

which is a factor price frontier associated with the agricultural technology. Substituting (14) into (12) and (13), l_{at} and k_{at} are represented respectively as

$$l_{at} = \overline{c}(1-\gamma)\frac{1}{w_t}, \tag{15}$$

$$k_{at} = \overline{c}\gamma\frac{1}{r_t}. \tag{16}$$

The capital good market clears if $k_{at} + n_t = k_t$. From (16), the number of intermediate goods is written as

$$n_t = k_t - \overline{c}\gamma\frac{1}{r_t}. \tag{17}$$

The labor market clearing condition, $l_{at} + n_t a x_t = 1$, and (15) yield

$$x_t = \frac{1}{an_t}\left[1 - \overline{c}(1-\gamma)\frac{1}{w_t}\right]. \tag{18}$$

The zero profit condition (8) and (18) provide another expression of n_t:

$$n_t = \frac{1}{\sigma - 1}\left[\frac{w_t}{r_t} - \overline{c}(1-\gamma)\frac{1}{r_t}\right]. \tag{19}$$

By (17) and (19),

$$k_t = \frac{1}{\sigma - 1}\frac{w_t}{r_t} + \overline{c}\left(\gamma - \frac{1-\gamma}{\sigma - 1}\right)\frac{1}{r_t}. \tag{20}$$

In the analysis below, I impose an assumption on γ and σ for simplicity:

$$\gamma = 1/\sigma. \tag{A.1}$$

Under (A.1), (20) is equal to

$$k_t = \frac{1}{\sigma - 1}\frac{w_t}{r_t}. \tag{21}$$

By (2), (3), (4), (8), and (21), the labor wage, w_t, the price of capital, r_t, and the quantity each intermediate good firm produces, x_t, can be represented as a function of capital:

$$r_t = A\frac{1}{\sigma}k_t^{-\frac{\sigma-1}{\sigma}}, \tag{22}$$

$$w_t = A\frac{\sigma-1}{\sigma}k_t^{\frac{1}{\sigma}}, \tag{23}$$

$$x_t = \frac{\sigma}{\sigma-1}\frac{1}{k_t}. \tag{24}$$

By (23), the range of capital that is consistent with $w_t \geq \overline{c}$ is given as

$$k_t \geq \left(\frac{\overline{c}}{A}\frac{\sigma}{\sigma-1}\right)^{\sigma} \equiv \overline{k}.$$

The number of intermediate goods is also represented as a function of capital:

$$n_t = k_t - \frac{\overline{c}}{A}k_t^{\frac{\sigma-1}{\sigma}}, \tag{25}$$

which is increasing in k_t. The increase of capital reduces the fixed cost to enter the intermediate goods market through the reduction of the price of capital. More entry to the market increases the number of intermediate goods and decreases the quantity that each firm produces. The labor wage is increasing in capital because labor becomes relatively scarce when more capital is supplied.

By (6), (7), (11), and (23)–(25), the supply of and the consumption demand for the manufacturing good are represented, respectively, by

$$X_t = \frac{\sigma}{\sigma-1}\left(k_t^{\frac{1}{\sigma}} - \frac{\overline{c}}{A}\right)^{\frac{\sigma}{\sigma-1}},$$

$$c_{mt} = \left(k_t^{\frac{1}{\sigma}} - \frac{\overline{c}}{A} \frac{\sigma}{\sigma - 1} \right) \left(k_t^{\frac{1}{\sigma}} - \frac{\overline{c}}{A} \right)^{\frac{1}{\sigma - 1}}.$$

The market clearing condition of the manufacturing good, $X_t = c_{mt} + k_{t+1}$, gives the supply of capital at period $t + 1$:

$$k_{t+1} = \frac{1}{\sigma - 1} k_t^{\frac{1}{\sigma}} \left(k_t^{\frac{1}{\sigma}} - \frac{\overline{c}}{A} \right)^{\frac{1}{\sigma - 1}} \equiv \Psi(k_t), \tag{26}$$

which represents the dynamic equation of capital.

In addition to the dynamics of capital, labor migration from traditional agriculture in rural areas to the modern intermediate goods sector in urban areas is one of the primary interests of this paper. This labor reallocation along with capital accumulation is captured by l_{at}. By (15) and (23), the labor share in agriculture is given by

$$l_{at} = \frac{\overline{c}}{A} k_t^{-\frac{1}{\sigma}}, \tag{27}$$

which is decreasing in capital.

3.2 Low-income case

Let us consider the case of $w_t < \overline{c}$, which is equivalent to $k_t < \overline{k}$. In this case, all the income is spent on the agricultural good. By the agricultural good market clearing condition, $w_t = y_{at}$, the production function (1), the capital-labor ratio (4), and the factor price frontier (14), l_{at} is given by

$$l_{at} = 1 - \gamma, \tag{28}$$

and $k_{at} = \gamma(w_t/r_t)$. Note that the agricultural labor share is constant and independent of capital, which is in contrast to the case of $w_t \geq \bar{c}$. By following the same step as in the case of $w_t \geq \bar{c}$, the capital good and labor market clearing conditions, and the zero profit condition (8) imply that

$$n_t = \frac{1}{\sigma} k_t, \quad X_t = \frac{\sigma^{-\frac{1}{\sigma-1}}}{\sigma - 1} k_t^{\frac{1}{\sigma-1}}.$$

The price of capital, r_t, the labor wage, w_t, and the quantity that each intermediate good firm produces, x_t, are the same as in (22), (23), and (24), respectively. Because $c_{mt} = 0$, the manufacturing good market clears if $k_{t+1} = X_t$. The supply of capital at period $t+1$ is, therefore,

$$k_{t+1} = \frac{\sigma^{-\frac{1}{\sigma-1}}}{\sigma - 1} k_t^{\frac{1}{\sigma-1}} \equiv \Phi(k_t). \tag{29}$$

The results of this section are summarized in the following proposition.

Proposition 1 *If $k_t \geq \overline{k}$, the dynamic equation of capital is described by Ψ in (26) and the labor share is decreasing in capital as shown by (27). If $k_t < \overline{k}$, the dynamic equation is described by Φ in (29) and the labor share is constant as shown by (28).*

Before discussing the equilibrium dynamics of capital, I make remarks on the relationship between the agricultural labor share and the level of capital, depicted in Figure 1. The income elasticity of the demand for the agricultural good plays a crucial role. In the regime where $k_t \geq \overline{k}$, the income elasticity is less than one and the labor share is decreasing in capital.[7] As capital is accumulated, it is available at a less expensive price and used intensively in agriculture. The intensive use of capital in agriculture enhances its average productivity of labor. Because income increases but the demand for the agricultural good stays constant at $\bar{c}$, labor is reallocated from the traditional

[7]Because I am focusing on the case of $\alpha = 0$, the income elasticity is zero. The result remains unchanged even though the elasticity takes some positive value less than one.

agricultural sector to the modern intermediate goods sector in urban areas. Although this result is not the first one showing that, in a closed economy, the improvement of the average productivity of labor in agriculture reduces its labor share, many previous studies analyze the effects of an exogenous change of agricultural labor productivity on the labor share in agriculture.[8] In this paper, the average productivity of labor in agriculture is endogenously determined through the use of capital supplied by the capital good sector in urban areas and, moreover, the size of the capital good sector is also determined endogenously because the productivity in the manufacturing sector is determined by the free entry and exit of firms to the intermediate goods market.

[Figure 1 around here]

In contrast with the case of $k_t \geq \overline{k}$, the income elasticity is exactly equal to one for $k_t < \overline{k}$, and the agricultural labor share is constant at $1 - \gamma$.[9] The structural change starts at $k_t = \overline{k}$. As capial increases, the economy shifts labor from traditional agriculture to the modern intermediate goods sector, and eventually, the labor share in agriculture becomes substantially small. Such rural-to-urban migrations along the development process have been experienced by most developed countries. The next section analyzes whether the economy realizes structural change along the equilibrium dynamics.

4 Equilibrium Dynamics and Structural Change

The dynamic equation is described by $\Phi(k_t)$ if $k_t < \overline{k}$, and $\Psi(k_t)$ if $k_t \geq \overline{k}$. In either case, it is an increasing function of k_t. The increase of capital lowers its price and reduces

[8]For example, Matsuyama (1992) and Eswaran and Kotwal (1993) show that an exogenous improvement of the agricultural TFP releases labor from agriculture to manufacturing.

[9]If the preference were homothetic and represented by a Cobb-Douglass utility function, $u(c_{at}, c_{mt}) = c_{at}^{\alpha} c_{mt}^{1-\alpha}$, then the labor share would always be $\alpha(1-\gamma)$ for any capital levels.

the fixed cost to enter the intermediate goods market. This induces more firms to enter the market and create new intermediate goods. The manufacturing sector can use an increased variety of differentiated intermediate goods, which improves the productivity in the sector and promotes capital accumulation. Although the dynamics of capital depend on all the parameters, σ, $\overline{c}$, and A, the role of σ is crucial. Because it is difficult to characterize the relationship between all parameters and dynamics comprehensively, I illustrate some interesting cases where there is only one steady state other than $k = 0$, providing numerical examples.

[Figure 2 around here]

Figure 2 depicts a case where σ is sufficiently smaller than two. Because the markup rate that the intermediate goods firms can set is high for small values of σ, the reduction of the fixed cost caused by a capital increase rapidly facilitates entry into the intermediate goods market, thereby accelerating capital accumulation. This mechanism creates both virtuous and vicious circles. In Figure 2 (a), $\overline{k} > k^*$, where k^* is the steady state capital level given by $\Phi(k^*) = k^*$.[10] The economy collapses to $k = 0$ if $k_0 < k^*$. If $k_0 > k^*$, on the other hand, the economy continues to grow, and the labor share in agriculture becomes smaller and smaller. Depending on the parameters, $\overline{k}$ may be smaller than the steady state capital level. Figure 2 (b) illustrates such a case, where k^{**} is defined by $\Psi(k^{**}) = k^{**}$.[11] The dynamics are almost the same as in the case of Figure 2 (a). While the economy falls into the poverty trap if $k_0 < k^{**}$, it experiences never-ending growth if $k_0 > k^{**}$.

[Figure 3 around here]

[10] For example, if $\sigma = 1.5$, $\overline{c} = 0.5$, and $A = 1$, then the dynamics correspond to Figure 2 (a).
[11] If $\sigma = 1.5$, $\overline{c} = 0.5$, and $A = 2$, then dynamics correspond to Figure 2 (b).

If σ is sufficiently larger than two, the dynamics of capital are illustrated by Figure 3. Because σ is large, the decrease of the fixed cost caused by a capital increase does not have a strong effect on facilitating new entries. Figure 3 (a) draws a case where $k^* < \overline{k}$.[12] For any $k_0 > 0$, the economy converges to $k = k^*$. Because $k^* < \overline{k}$, the agricultural labor share is $1 - \gamma$ and individuals consume only the agricultural good at the steady state. Figure 3 (b) corresponds to the case where $\overline{k} < k^{**}$.[13] Although the agricultural labor share stays at $1 - \gamma$ and individuals spend all their income on the agricultural good until $k_t < \overline{k}$, the economy experiences structural change and individuals consume both the agricultural and manufacturing goods after k_t exceeds $\overline{k}$. Nonetheless, the economy stagnates after the capital level reaches k^{**}.[14]

The dynamic analysis of this model has some implications for a policy that raises the value of A, the agricultural TFP, permanently. A rise in A shifts $\Psi(k_t)$ upwards and lowers $\overline{k}$. Suppose that the capital dynamics of the economy are depicted by Figure 2 (a). A permanent rise of A can change the regime of the economy to that depicted in Figure 2 (b), and shrinks the range of capital that makes the economy fall into the poverty trap.[15] While the policy that raises A can help the economy converging to $k = 0$ to escape from the poverty trap if the economy still has capital stock such that $k_t > k^{**}$, the policy is useless otherwise. The effect of the same policy is also analyzed in the same way for the economy depicted by Figure 3 (a). A permanent rise in A can change the regime of the economy to that drawn by Figure 3 (b).[16] The capital starts to increase and, at the point that $k_t = \overline{k}$, the economy starts the labor reallocation

[12] If $\sigma = 4$, $\overline{c} = 0.5$, and $A = 1$, then the dynamics correspond to Figure 3 (a).

[13] If $\sigma = 4$, $\overline{c} = 0.5$, and $A = 2$, then the dynamics correspond to Figure 3 (b).

[14] If $\sigma = 2$, the economy always converges to $k = 0$ because $\Psi'(k) < 1$ and $\Phi'(k) < 1$ for all $k \geq 0$.

[15] Note that k^* is independent of A, $\overline{k}$ is always decreasing in A, and that k^{**} is also decreasing in A when σ is sufficiently small. A sufficient rise of A makes k^{**} less than k^*, and shrinks the range of the poverty trap from $[0, k^*]$ depicted in Figure 2 (a) to $[0, k^{**}]$ in Figure 2 (b).

[16] The regime switching from Figure 2 (a) to 2 (b) and Figure 3 (a) to 3 (b) also occurs when σ changes and A is kept constant at a certain level.

from traditional agriculture to the modern intermediate goods sector in urban areas, although this process stops at $k_t = k^{**}$. These analyses above suggest that policies that improve the agricultural TFP may contribute the joint evolution of capital increase and labor reallocation, but its effect is limited. Economic growth and structural change may or may not be observed after implementing such policies, and even when they are observed, they end eventually if σ is sufficiently large, as illustrated in Figure 3.

These circumstances may cause a controversy over the role of agriculture on economic development. The model predicts that economic development coincides with the improvement of the average productivity of labor in agriculture and the declining labor share in the sector. However, it does not imply that a high average productivity of labor in agriculture is a precondition for structural change and economic development, because y_{at}/l_{at}, l_{at}, and k_{t+1} are all jointly determined. If the government can implement a policy that improves the agricultural TFP, it does not have a negative effect on economic development but does not necessarily guarantee that the economy can escape from a poverty trap.[17]

Because some readers may wonder how robust the results are if $\alpha > 0$ in (9), I mention the results under this case. Under (A.1), for $k_t \geq \overline{k}$, the dynamic equation of capital and the agricultural labor share are given respectively by

$$k_{t+1} = \frac{1}{\sigma - 1} k_t^{\frac{1}{\sigma}} \left[\left(1 - \alpha \frac{\sigma - 1}{\sigma} \right) k_t^{\frac{1}{\sigma}} - (1 - \alpha) \frac{\overline{c}}{A} \right]^{\frac{1}{\sigma - 1}},$$

$$l_{at} = \alpha \frac{\sigma - 1}{\sigma} + (1 - \alpha) \frac{\overline{c}}{A} k_t^{-\frac{1}{\sigma}},$$

[17] In his literature review, Gollin (2010) describes that although the positive correlation between agricultural productivity and economic development is empirically well established, the causality is very unclear and the effectiveness of policies that emphasize agriculture is controversial.

and for $k_t < \overline{k}$, everything is the same as in the case of $\alpha = 0$. The qualitative results remain unchanged even though $\alpha > 0$.

5 Concluding Remarks

This paper has analyzed the relationship between economic development and structural change by focusing on the bidirectional rural-urban interactions. On one hand, because food is a necessity, the improvement of agricultural productivity may be a precondition of accomplishing structural change and sustained growth. On the other hand, technological advances in non-agriculture enhance agricultural productivity through the provision of industrial intermediate inputs. This paper has presented a model that incorporates both of the two views and capital accumulation. As capital accumulates, agriculture intensively uses it to produce a given amount, and labor is released from agriculture. People migrate to urban areas to innovate new intermediate inputs, which in turn promotes further capital accumulation and capital intensive agriculture. This mechanism creates the possibility of a poverty trap as well as permanent growth. If the economy starts with a low level of capital stock, then agriculture is labor intensive, people do not migrate to urban areas to create new intermediate inputs, and capital accumulation is never facilitated. By contrast, once sufficient capital is accumulated, the economy can experience sustained growth. Considering a policy that can help the economy escape from a poverty trap caused by the rural-urban interdependence remains for future research.

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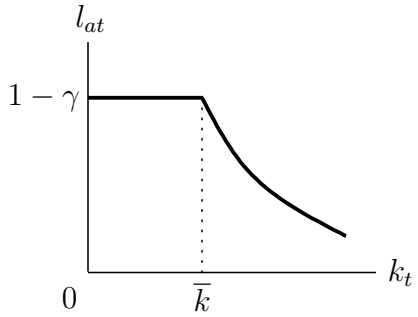

Figure 1: Agricultural labor share and capital accumulation

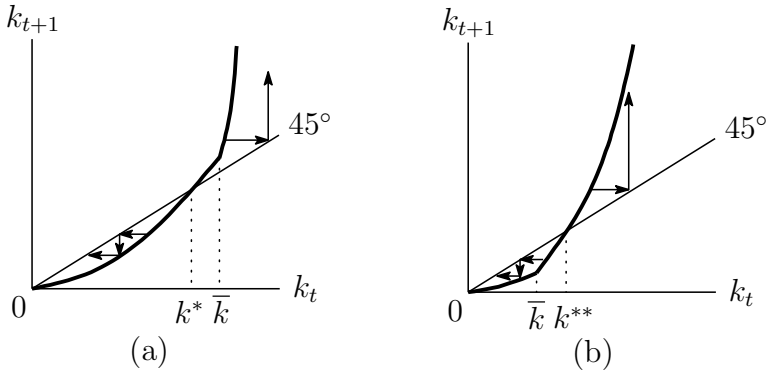

Figure 2: Dynamics for a small σ

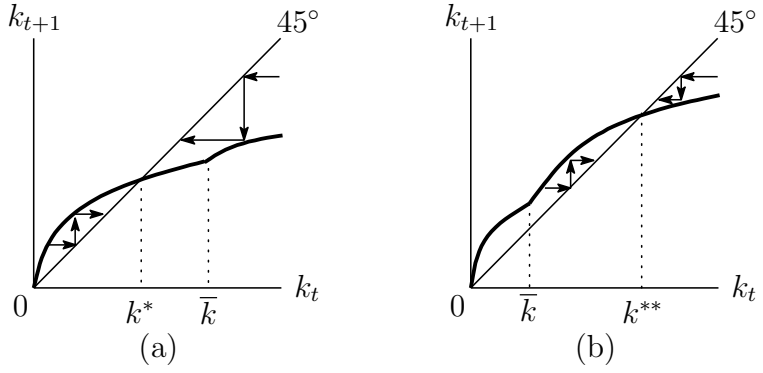

Figure 3: Dynamics for a large σ